1967

The Effect of Interval Running in Water on leg Strength and Circulorespiratory Efficiency

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THE EFFECT OF INTERVAL RUNNING IN WATER ON LEG STRENGTH AND CIRCULORESPIRATORY EFFICIENCY

BY

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A thesis submitted
in partial fulfillment of the requirements for the
degree Master of Science, Major in
Physical Education, South Dakota
State University

1967

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THE EFFECT OF INTERVAL RUNNING IN WATER ON LEG STRENGTH
AND CIRCULORESPIRATORY EFFICIENCY

Abstract

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Under the supervision of Associate Professor Glenn E. Robinson

The purpose of this investigation was to determine the effects of progressive interval running in water on leg strength and circulorespiratory efficiency.

During the fall semester of the 1966-67 school year, 20 junior males enrolled in the basic physical education program, at Washington Senior High School, Sioux Falls, South Dakota, were given parental permission to participate in this investigation. The subjects had participated in varsity athletics during the 1965-66 school year. The subjects were equated into two groups from results of an oxygen consumption test by the matched pairs method. The track pill box method was used to denote designation of the experimental (Group R) and the control (Group C) groups.

The experimental group participated in an interval training program of running through water at a depth midpoint from the top of the patella to the crest of the ilium. The interval distance of 40 yards and the rest interval of 60 seconds remained the same in the training program. The subjects ran at 3/4 their maximum running speed in water determined by an initial all-out effort. The training program began with four running intervals which were increased every second day by one running interval to intensify the training program.

The control group carried on normal daily activity.

The experimental and control groups were administered initial and final tests on oxygen consumption, hip flexion, hip extension, knee extension, and resting pulse rates.

The *t* test was used to denote statistical significance between experimental and control groups. The *t* test was also employed to denote statistical significance from within the experimental and the control group.

The statistical analysis indicated the methods of training in water used in this experiment improved hip flexion strength, knee extension strength, and lowered resting pulse rates. The training method did not significantly improve oxygen consumption and hip extension strength.

THE EFFECT OF INTERVAL RUNNING IN WATER ON LEG STRENGTH

AND CIRCULORESPIRATORY EFFICIENCY

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser Date

Head, Physical Education Department Date

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to Professor Glenn E. Robinson, thesis adviser, for his guidance in the preparation of this study.

Appreciation is also extended to Mr. William Fritz for his assistance in this study.

The author wishes to express gratitude to the YWCA in Sioux Falls, South Dakota, for the use of its pool facilities.

The author also wishes to express gratitude to the young men who participated in the study as subjects.

RJS

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Chapter I

INTRODUCTION

Justification of Study

Research in physical education and athletics has been concerned with the efficiency of the human body to perform highly skilled movements. The modern athlete is trained by very strenuous workout schedules and by scientific training methods. Athletic coaches are constantly trying to develop strength and endurance in their athletes by these strenuous scientific training methods. Muscular strength and circulorespiratory efficiency are reasoned to be common desirable factors in physical components for an athlete.

Athletic associations at the state level usually set starting dates for the fall competitive sports. The interscholastic coach then puts the athletes through a vigorous physical training program in preparation for early competition. Many times this program is too advanced for the athletes so that the health of the young athletes may be impaired.

If the athlete attempts a vigorous training regime to become ready for a competitive situation, psychological and physiological stress might be detrimental after a three-month period of inactivity.

A pre-season training program directed toward developing the athlete's circulorespiratory efficiency and leg strength could prepare the athlete for the extreme stress of early practice sessions. Because of the great overload placed upon the circulorespiratory system without a gradual build up of the work load the non-prepared athlete is in danger when hard physical training programs are administered. Riedman[1] states, "Oxygen sufficient to meet the needs of work can reach muscles only if the circulation is adequate for transporting it!"

[1] Sarah R. Riedman, Physiology of Work and Play, p. 221.

It is with the above factors in mind that this investigation was conducted to evaluate a short pre-season interval training program to develop leg strength and circulorespiratory efficiency.

Statement of Problem

The purpose of this investigation was to determine the effects of progressive interval running in water on leg strength and circulorespiratory efficiency.

Limitations of Study

1. This study was limited to volunteers from the physical education program at Washington Senior High School in Sioux Falls, South Dakota.

2. The subjects were high school juniors who had participated in a varsity sport during the previous year.

3. The length of the training program was three weeks.

4. The subjects were encouraged not to take part in any other physical training programs.

Definition

Water: The term water as used in this study refers to a body of water in which a depth range was available. The range in depth was the midpoint between the top of the patella and the crest of the ilium for each subject. An indoor swimming pool was employed in this investigation.

Chapter II

REVIEW OF RELATED STUDIES

Introduction

A survey of studies that concern leg strength, circulorespiratory efficiency, interval training and the length of rest in interval training are reported in this chapter.

Report of Pertinent Findings

Coleman[2] being concerned about strength concluded that

[2]James W. Coleman, "The Differential Measurement of the Speed Factor in Large Muscle Activities," Research Quarterly, Vol. VIII No. 3 October, 1937, p. 130.

strength is a distinct factor in individual athletic performance. The author also indicated that speed and strength are recognized as major factors in athletic success. However, the problem revolves about how to increase strength and yet retain the speed of muscular contractions.

Weight training to develop strength left the erroneous opinion that weight training would slow down muscular contractions. Zorbas and Karpovich[3] found weight lifting increased rotary speed of

[3]William S. Zorbas and Peter Karpovich, "The Effect of Weight Lifting Upon the Speed of Muscular Contractions," Research Quarterly, May 1951, pp. 145-148.

the arm at the .01 level of significance.

Muller[4] states various progressive training programs may be

[4]E. D. Muller, "Training Muscle Strength," Ergonomics, February, 1959, pp. 216-222.

used to increase strength. The stimulus for increasing strength is not fatigue, but an increase in tension over that previously exerted.

Shvartz[5] in testing increase of heart rate in isometric con-

[5]Esar Shvartz, "Effect of Isotonic and Isometric Exercises on Heart Rate," Research Quarterly, March 1966, pp. 121-125.

tractions at one half of maximum resistance, two thirds maximum load, and maximum load found a mean heart rate increase of 136.6 for isometric maximum contraction. The heart rate mean for one half resistance isometric contraction was 99.1 and the mean for two thirds maximum load was 103. The mean resting pulse was 71.8.

Karvonen[6] states cardiovascular efficiency is an important

[6]M. J. Karvonen, "Problems of Training of the Cardiovascular System," Ergonomics, February, 1959, pp. 207-215.

factor to the competitive athlete. It is doubtful that weight training increases the efficiency of the cardiovascular system. The cardiovascular system may be considered trained when a large cardiac output is developed. Training the cardiovascular system must also be associated with a high intake of oxygen. Structural chemical and functional change occurs only when training takes place at high pulse rate levels.

Sprecher[7] in reviewing the Gerschler-Reindell Law cites:

[7]P. Sprecher, "Visit with Dr. Woldemar Gerschler," Run Run Run, pp. 150-151.

> After 3000 experiments had been carried out for 21 days, it appeared that the heart did not at any time surpass 180 beats per minute in the course of a physical exercise - 180 beats represents a limit.
>
> From this point (180 beats) the heart is permitted 1 minute, 30 seconds to return to 120-125 beats per minute; if it takes longer, it is because the effort demanded is (1) either too violent, or (2) too long.
>
> In the second case, the distance to be run should be shortened. One minute, 30 seconds also represents a limit. When the pulse has returned to 120-125 beats per minute, the runner is able to and ought to begin running again, even if the heart took less than 1 minute, 30 seconds to recover.
>
> In resume, what is most important is:
>
> 1. Bring the heart to 120 beats per minute by a preliminary warmup not only by running on the track but also by exercise of all kinds in order to begin the workout effectively.
>
> 2. From this point, the runner does a given distance - 100, 150 or 200 meters in a given time which will bring the heart up to about 170-180 beats per minute.
>
> 3. Soon afterward, the heart ought to take a maximum of 1 minute, 30 seconds to return to about 120 beats per minute. This time could be shortened, however, but what is important is the return of the heart to 120-125 beats per minute. When this occurs, the runner should begin running again.

In a book edited by Wilt[8], Diem verifies the Gerschler-

[8]Fred Wilt, Run Run Run, p. 182.

Reindel Law in stating that recovery must last only until the breathing and the heart are calm again and a feeling of freshness is felt.

Immediately after that, the work (activity) must be resumed so that the athlete does not become unaccustomed to strenuous work before he has completely recovered.

Roskamm, Reindell, and Keul[9] in summarization of the physiology of general endurance concluded that training for organic stamina or endurance, in this case of the heart, two methods may be used, extended efforts and interval training. Interval training requires far less time; therefore, it seems to be much more practical.

[9]Dr. H. Roskamm, Prof. Dr. H. Reindell, and Dr. J. Keul, "Physiological Fundamentals of Training Methods," Run Run Run, p. 193.

Use of interval training in the athletic world is further substantiated by Roskamm, Reindell, and Keul[10] in this commentary:

> In those forms of sports, where the capacity of the leg muscles is of prime importance, interval training may be used to effect the requirements of speed, strength and endurance of the organism. This latter through the effect of increased circulatory demands. Interval training is thus a good conditioner for all field games such as soccer, football, etc.

[10]Ibid., pp. 195-196.

Summary

The review of pertinent findings involving leg strength, cardiorespiratory efficiency, interval training, and the length of recovery time seems to bear out that a training program causes gains in leg strength and circulorespiratory efficiency.

Chapter III

PROCEDURE FOR OBTAINING DATA

Introduction

The purpose of this investigation was to determine the effect of running in water on circulorespiratory efficiency and on leg strength. The subjects, oxygen consumption test, leg strength tests, establishment of resting pulse rate, and the training program are described in this chapter.

Subjects

The subjects for the study were selected from the 11th grade male physical education classes at Washington Senior High School, Sioux Falls, South Dakota. The subjects had all competed in a varsity sport during their sophomore school year.

Thirty-two males volunteered to participate in the study. The candidates were asked to obtain parental consent for participation in the study. Twenty students who volunteered were given parental permission to take part in the investigation.

The subjects were screened for any physical defects by a private conference with them concerning their past health history.

The 20 subjects were divided into two groups by the results obtained from an oxygen consumption test, and the groups were equated by the matched pairs method. Selection of the experimental group and the control group was then achieved by the track pill box method.

The subjects in the control group are hereafter referred to as Group C (Control). The subjects in the experimental group are hereafter referred to as Group R (Run).

The training program took place from October 3, 1966, to October 21, 1966.

Measurements

The initial tests on oxygen consumption, hip flexion, hip extension, knee extension and resting pulse rates were administered on October 1, 1966. The final testing on the above parameters for the experimental group was administered on October 24, 1966, and to the control group on October 25, 1966.

Oxygen Consumption Test

Each subject was readied for the oxygen consumption test in the following manner. A nose clamp was secured to the nose of the subject as he stood on the Collins treadmill. The subject then inserted in his mouth a sterilized rubber mouth-piece connected to two hoses which led to a 13.5 liter closed circuit Collins respirometer. A kymograph attached to the respirometer recorded graphically the oxygen consumed. Oxygen was available in a cylinder coupled to the respirometer by a rubber hose. Oxygen was induced into the respirometer to keep an adequate supply of oxygen in the respirometer bell during testing.

Each subject breathed from the closed circuit respirometer for four minutes to establish normal resting oxygen consumption which was being recorded graphically by the kymograph. Each subject then performed for one minute a standardized treadmill run at seven miles per hour up a 10 percent grade. After completion of the one standardized treadmill run, the subject stood on the treadmill for four minutes breathing from the closed circuit respirometer to measure oxygen consumed during recovery which was recorded graphically by a kymograph.

A line of best fit was drawn along the bottom of the spikes on the kymograph recording of the subject's test to establish uncorrected cubic centimeters of oxygen consumed per minute during rest and recovery. The uncorrected cubic centimeters of oxygen consumed at rest were subtracted from the uncorrected cubic centimeters consumed in recovery. The uncorrected cubic centimeters were then multiplied by two because a 13.5 liter respirometer was used. A correction factor derived from barometric pressure and oxygen temperature was used to determine the corrected amount of cubic centimeters of oxygen debt repaid by each subject.

Leg Strength Tests

The subjects were tested for hip flexion, hip extension, and knee extension in accordance with instructions by Clarke's[11] cable

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[11] H. Harrison Clarke, A Manual: Cable-Tension Strength Tests, pp. 24, 26 and 29.

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tension strength tests for these three actions.

Resting Pulse Rate Test

The subjects were seated in an arm chair school desk with a quiet environment for five minutes. At the end of five minutes the carotid pulse was monitored for 15 seconds and multiplied by 4 to establish resting pulse. Pulse rates were monitored four times in the initial and the final test with the mean of the initial tests and the mean of the final test representing the resting pulse rate for each subject.

Interval Training Program

The interval training program was conducted in the YWCA swimming pool at Sioux Falls, South Dakota.

During the interval running in water training program the experimental group had 15 training sessions at 2:30 P.M. each training day in a three-week period.

The interval distance of 40 yards and the 60 second recovery time in this study remained constant. Overloading was achieved by progressively increasing the number of runs per sessions. The subjects in Group R ran one all-out time trial on the first training day. Each subject's interval training speed was 3/4 of the time trial run. The work load was increased in severity every two training days with exception of training day one in which the all-out timed trial was performed. Training day one began with four runs and 60 seconds recovery interval between each run. During the 15 training day period the work load was progressively intensified by adding one running interval on the 3rd, 5th, 7th, 9th, 11th, 13th, and 15th training days. A stop watch was utilized to establish consistent pace by Group R and to establish exact recovery time between running intervals. The final run each day was performed at maximum effort. Group R was given light stretching exercises before each training session to loosen up muscle groups in an attempt to prevent possible muscle injuries to the subjects. Water depth was at the midpoint between the top of the patella and the crest of the ilium for each subject.

Chapter IV

ANALYSIS OF DATA

Introduction

The statistical analysis of the data,[12] (oxygen debt repaid

[12]The data appears in Appendixes A-E.

during recovery, hip flexion, hip extension, knee extension, and resting pulse rates) is presented in this chapter.

Scoring of Data

The raw scores obtained from oxygen consumed at rest and in recovery from the one minute standardized treadmill run were recorded graphically. The differences between the amount of oxygen used at rest and in recovery were doubled because of the use of a 13.5 liter respirometer. A correction factor, computed from barometric pressure and oxygen temperature, was utilized to compute the corrected amount of oxygen consumed to standard temperature and pressure. Multiplication of the cubic centimeters of oxygen used by the correction factor determined the corrected amount of cubic centimeters used in oxygen debt repaid.

The pulse rates during rest required no conversion in this study.

The raw scores (tension pounds)obtained in the hip flexion, hip extension, and knee extension tests were converted to pounds.

Reliability of Data

A standard procedure for administration of the oxygen consumption test was supervised and approved by the Physical Education Department at South Dakota State University. No reliability coefficients were computed for the oxygen consumption test. A standard procedure of checking the respirometer, soda lime crystals, hoses and valves, mouth pieces and pressure in the cylinder was followed in this investigation. A number of pilot tests were conducted to enable the investigator to standardize his procedure in operating the closed circuit respirometer.

No reliability coefficients were recorded for resting pulse rates due to variable factors which influence pulse rate.

The objectivity coefficient for the hip flexion test was .90 and .94 for the hip extension test. The objectivity coefficient for the knee extension test was .94.

Analysis of Data

The investigator employed the statistical method as described by Garrett[13] to determine the critical ratio (t ratio).

[13]Henry E. Garrett, Elementary Statistics, p. 123.

The analysis of data for this investigation was calculated from the standard error of the difference between means in the final experimental group tests and the final control group tests. The five percent level of significance was chosen, and eighteen degrees of freedom were present in this study. The critical ratios that were significant at or beyond the five percent level of significance caused the rejection of the null hypothesis. The null hypothesis was rejected if the critical ratio was equal to or greater than 2.10.

The investigator further statistically analyzed the data by a comparison within Group R and within Group C. The standard error of the difference between initial and final means was used to obtain critical ratios within Group R and within Group C. The five percent level of significance was chosen, and eighteen degrees of freedom were present in comparison. The critical ratios that were significant at or beyond the five percent level of significance caused the rejection of the null hypothesis. The null hypothesis was rejected if the critical ratio was equal to or greater than 2.10.

Findings

Oxygen Consumption (Between Groups)

The critical ratio of the difference between the experimental group mean and the control group mean (Table I) was computed and found to be .35 and, therefore, was not statistically significant at the .05 level of significance. The null hypothesis was accepted.

Table I

Summary of *t* Test of Mean Difference Between Groups

Measurements	Final Means	Mean Difference	df	C. R.	Level of Significance
Oxygen Consumption (Cubic Centimeters)					
Group R	2078.2	27.8	18	.35	N.S.
Group C	2050.4				
Hip Flexion (Pounds)					
Group R	154.4	18.4	18	8.07	.01
Group C	136.0				
Hip Extension (Pounds)					
Group R	133.7	1.6	18	.51	N.S.
Group C	135.3				
Knee Extension (Pounds)					
Group R	253.6	4.25	18	10.61	.01
Group C	208.5				
Resting Pulse Rates					
Group R	68.8	7.6	18	6.53	.01
Group C	76.4				

<u>Hip Flexion</u> (Between Groups)

The critical ratio of the difference between the experimental group mean and the control group mean (Table I) was computed and found to be 8.07 and, therefore, was statistically significant beyond the .05 level of significance. The null hypothesis was rejected.

<u>Hip Extension</u> (Between Groups)

The critical ratio of the difference between the experimental group mean and the control group mean (Table I) was computed and found to be .51 and, therefore, was not statistically significant at the .05 level of significance. The null hypothesis was accepted.

<u>Knee Extension</u> (Between Groups)

The critical ratio of the difference between the experimental group mean and the control group mean (Table I) was computed and found to be 10.61 and, therefore, was statistically significant beyond the .05 level of significance. The null hypothesis was rejected.

<u>Resting Pulse Rate</u> (Between Groups)

The critical ratio of the difference between the experimental group mean and the control group mean (Table I) was computed and found to be 6.53 and, therefore, was statistically significant beyond the .05 level of significance. The null hypothesis was rejected.

<u>Oxygen Consumption</u> (Within Groups)

The critical ratio of the difference between the initial mean and the final mean (Table II) was computed to be .60 for Group R and .61 for Group C. Group R was not statistically significant at the .05 level of significance. The null hypothesis, therefore, was

Table II

Summary of t Test for Mean Difference Within Groups

Measurements	Initial Mean	Final Mean	Mean Difference	df	C. R.	Level of Significance
Oxygen Consumption (Cubic Centimeters)						
Group R	2248.2	2078.2	-170	18	.60	N.S.
Group C	2219.2	2050.4	-168.8	18	.61	N.S.
Hip Flexion (Pounds)						
Group R	130.9	154.4	+ 23.5	18	2.98	.01
Group C	118.9	136	+ 17.1	18	2.00	N.S.
Hip Extension (Pounds)						
Group R	119.6	133.7	+ 14.1	18	1.44	N.S.
Group C	118.3	135.3	+ 17	18	2.34	.05
Knee Extension (Pounds)						
Group R	178.8	253.6	+178.8	18	4.28	.01
Group C	164.5	208.5	+ 44	18	3.38	.01
Resting Pulse Rate						
Group R	80.8	68.8	+ 12	18	2.11	.05
Group C	80	76.4	+ 3.6	18	1.33	N.S.

accepted for Group R. Group C was not statistically significant at the .05 level of significance. The null hypothesis, therefore, was accepted for Group C.

Hip Flexion (Within Groups)

The critical ratio of the difference between the initial mean and the final mean (Table II) was computed to be 2.98 for Group R and 2.00 for Group C. Group R was statistically significant beyond the .05 level of significance. The null hypothesis, therefore was rejected for Group R. Group C was not statistically significant at the .05 level of significance. The null hypothesis was accepted for Group C.

Hip Extension (Within Groups)

The critical ratio of the difference between the initial mean and the final mean (Table II) was computed to be 1.44 for Group R and 2.34 for Group C. Group R was not statistically significant at the .05 level of significance. The null hypothesis, therefore, was accepted for Group R. Group C was statistically significant at the .05 level of significance. The null hypothesis, therefore, was rejected for Group C.

Knee Extension (Within Groups)

The critical ratio of the difference between the initial mean and the final mean (Table II) was computed to be 4.28 for Group R and 3.38 for Group C. Group R was statistically significant beyond the .05 level of significance. The null hypothesis, therefore, was rejected for Group R. Group C was statistically significant beyond the .05 level of significance. The null hypothesis, therefore, was rejected.

Resting Pulse Rate (Within Groups)

The critical ratio of the difference between the initial mean and the final mean (Table II) was computed to be 2.11 for Group R and 1.33 for Group C. Group R was statistically significant beyond the .05 level of significance. The null hypothesis, therefore, was rejected. Group C was not statistically significant at the .05 level of significance. The null hypothesis, therefore, was accepted.

Summary of Findings

Table I shows Group R and Group C final means, mean difference, degrees of freedom, critical ratio, and levels of significance. Table II shows comparisons from within Group R and Group C by initial and final means, mean difference, degrees of freedom, critical ratio, and levels of significance.

Statistically significant improvements were noted for hip flexion, knee extension, and for resting pulse rates.

Oxygen consumption and hip extension were not statistically significant in this study.

Discussion of Findings

The findings of this study seem to indicate the following: the effect of interval running in water seems to be an effective method of improving hip flexion strength and knee extension strength.

The lowering of the resting heart rate is in agreement with reported studies which indicates the endurance-trained athlete has lower resting heart rate levels.

Chapter V

SUMMARY

Problem

The purpose of this investigation was to determine the effects of progressive interval running in water, had on the improvement of leg strength and circulorespiratory efficiency.

Data

Subjects that participated in this investigation were junior males enrolled at Washington Senior High School, Sioux Falls, South Dakota, during the fall semester of 1966-67 academic year who had participated in varsity athletics during the 1965-66 academic year. The subjects were all in the basic physical education classes at Washington Senior High School. The twenty subjects obtained parental permission to participate in this investigation and were equated into two groups from the results of an oxygen consumption test by the matched pairs method. The designation of experimental (Group R) and control (Group C) groups was determined by the track pill box method. A three-week training program of interval running in water, with 15 training sessions, was administered to the experimental group. Each running interval was 40 yards in distance with a rest interval of 60 seconds between runs. The number of running intervals was progressively increased from 4 to 11 throughout the training program. The water was at a depth midpoint from the top of the patella to the crest of the ilium.

Oxygen consumption, hip flexion, hip extension, knee extension, and resting pulse rates were measured at the beginning of the training program and again at the end of the three-week training program.

The data from oxygen consumption, hip flexion, hip extension, knee extension, and resting pulse rates were analyzed by a *t* test between and within groups.

Findings

The analysis of data by the use of the *t* test found statistically significant difference between Group R and Group C in hip flexion, knee extension, and in resting pulse rates in favor of Group R. The *t* test found no statistical significance between Group R and Group C in oxygen consumption and hip extension.

Analysis of data by the use of *t* test applied within Group R and Group C noted the following results: (a) Group R and Group C showed no statistical significant improvement in oxygen consumption. (b) Group R showed statistical significant improvement in hip flexion strength. Group C showed no statistical significant improvement in hip flexion strength. (c) Group R showed no statistical significant improvement in hip extension strength. Group C showed statistical significant improvement in hip extension strength. (d) Group R and Group C both showed statistical significant improvement in knee extension strength. (e) Group R showed statistical significant improvement in resting pulse rates. Group C showed no statistical significant improvement in resting pulse rates.

Conclusions

The findings in this investigation indicate the training method in this experiment statistically improved hip flexion, strength, knee extension strength, and lowered the resting pulse rates of the experimental group. The training method did not statistically improve oxygen consumption and hip extension strength in this study.

Recommendations for Further Study

From results obtained in this study the investigator would like to make the following recommendations for further study:

That an investigation be conducted over a longer period of time with more training sessions.

That a more intensified program of running in water be established at the beginning of the training program.

That the number of running intervals per training sessions be increased daily.

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Appendix A

RAW DATA: OXYGEN CONSUMPTION (CC. OXYGEN)

	Initial	Final
Experimental (Group R)		
Subject Number		
1	1246	2125
2	1408	1190
3	1869	2380
4	1958	2550
5	2160	1260
6	2225	2175
7	2464	2040
8	2904	1348
9	3080	2790
10	3168	2924
	$\bar{\bar{x}} = 2248.2$	$\bar{\bar{x}} = 2078.2$
Control (Group C)		
Subject Number		
1	1068	1190
2	1672	1615
3	1780	1785
4	1958	2635
5	2112	1634
6	2225	1785
7	2225	2210
8	2816	2890
9	2992	2040
10	3344	2720
	$\bar{\bar{x}} = 2219.2$	$\bar{\bar{x}} = 2050.4$

Appendix B

RAW DATA: HIP FLEXION (POUNDS)

Experimental (Group R) Subject Number	Initial	Final
1	118	153
2	130	153
3	115	150
4	130	143
5	134	183
6	138	170
7	130	143
8	118	143
9	186	153
10	110	153
	$\bar{x} = 130.9$	$\bar{x} = 154.4$

Control (Group C) Subject Number	Initial	Final
1	105	143
2	167	166
3	115	126
4	98	113
5	108	116
6	110	110
7	118	140
8	130	150
9	125	143
10	113	153
	$\bar{x} = 118.9$	$\bar{x} = 136.0$

Appendix C

RAW DATA: HIP EXTENSION (POUNDS)

Experimental (Group R) Subject Number	Initial	Final
1	115	130
2	134	153
3	136	143
4	65	85
5	170	183
6	125	130
7	103	136
8	85	120
9	150	107
10	113	150
	$\bar{x}$ = 119.6	$\bar{x}$ = 133.7

Control (Group C) Subject Number	Initial	Final
1	115	146
2	134	130
3	120	130
4	120	133
5	103	106
6	87	113
7	110	146
8	136	140
9	118	156
10	140	153
	$\bar{x}$ = 118.3	$\bar{x}$ = 135.3

Appendix D

RAW DATA: KNEE EXTENSION (POUNDS)

Experimental (Group R) Subject Number	Initial	Final
1	150	196
2	204	280
3	187	270
4	180	305
5	216	280
6	180	245
7	167	250
8	147	220
9	197	245
10	160	245
	$\bar{x} = 178.8$	$\bar{x} = 253.6$

Control (Group C) Subject Number	Initial	Final
1	170	250
2	183	235
3	160	196
4	147	190
5	108	160
6	147	196
7	187	200
8	216	250
9	147	204
10	180	204
	$\bar{x} = 164.5$	$\bar{x} = 208.5$

Appendix E

RAW DATA: RESTING PULSE RATE

	Initial	Final
Experimental (Group E)		
Subject Number		
1	72	68
2	92	80
3	76	68
4	76	68
5	72	60
6	88	80
7	72	68
8	80	64
9	116	84
10	64	48
	$\bar{x} = 80.8$	$\bar{x} = 68.8$
Control (Group C)		
Subject Number		
1	76	76
2	84	72
3	84	80
4	76	76
5	88	84
6	72	68
7	84	80
8	76	76
9	72	68
10	88	84
	$\bar{x} = 80.0$	$\bar{x} = 76.4$